SOIL CONSERVATION

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CLEAN-UP week in the Ohio Valley follows the 1937 flood catastrophe. Hundreds of W. P. A. crews are at work resurrecting streets, water mains, and sewer lines from a choking blanket of mud. Refugees are trickling back into flood-stricken cities to survey in bewilderment the havoc in their homes. Two weeks have passed since the greatest flood of record swept down the Ohio Valley. The extent

NOTE.—The author is associate geologist, Section of Sedimentation Studies, Division of Research, Washington, D. C.

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of recovery already effected is astonishing—a tribute to the capacity of the American people to snap back from major disasters such as seldom strike twice in one century. By February 13, Louisville, Ky.—hardest hit of the major cities—has its main business section plastered with signs reading "Open for business", "Open—with heat", or "Business as usual."

Mud Left in the Cities

Nevertheless, telltale evidences remain, even in the best of places, to show what efforts the clean-up required. For instance, I sat in the coffee shop of a first-class hotel in the heart of Louisville, reopened only 2 days before, and saw in nooks and crevices a dried scum of mud that soap and water couldn't reach. Only paint can remove those blemishes. Two feet of water had stood on the floor of that coffee shop. Never before had the coffee shop been within a mile of the river.

The condition in which homes were left by receding flood waters is almost unbelievable until you've seen it. This flood was no respecter of property rights. Mansions of the well-to-do suffered in common with negro shanties. The flood was bad enough at the time, but what it left was even worse. Had the flood been only water the outlook might not be so gloomy. Rugs, for instance, and curtains dry fairly well in the sun. But suppose you found, as these flood victims have, an inch or two of fine sticky mud clinging to your floors, a plaster of mud on your wallpaper, in your bureau drawers, mud even inside your mattress? Imagine your grand piano with a film of mud on every moving part. I saw several in this condition, and dozens of automobiles being disassembled completely for cleaning. Wherever the yellow swirling flood water found its way, you may be sure that mud was left to tell the story.

Other Side of Story

The other side of this flood aftermath is not in the flood zone at all. Any casual observer may see it, as I did, in driving through the Miami Valley above Cincinnati and from that city to Louisville. Hundreds of thousands of incipient gullies have developed during the phenomenal 12 days of rain that started the mad flood waters on their way. Fields on end—literally—hundreds of fields plowed straight up and down the slopes showed miniature canyons, up to 4 inches deep, in every furrow. Occasional new gullies, somewhat larger, cut diagonally across the rows. Altogether these countless thousands of new erosion scars must represent soil losses of millions of tons in the 12 days of rain. Of particular significance too is the fact observed during a drive from Dayton through Cincinnati to Louisville that not a single field showed soil-conserving practices which were unmistakably recognizable as such. Certainly there was no terracing and scarcely any contour plowing. True, much of the land is now in grass. How closely it is grazed is demonstrated by a flock of more than 3 dozen sheep that I saw grazing on a 3-acre hillslope off 1-inch grass. And this area from Dayton to Louisville is in the heart of the Ohio Valley.

At the bottom of several slopes on which the rows ran straight uphill, I examined silt that appeared to duplicate that collected on Cincinnati streets. The small fan-shaped patches of silt left behind at the bottom of slopes could be only a small part of that eroded from the fields above. The rest was a contribution to the Ohio flood waters. Various fractions of it have been dropped by flood waters between those fields and the Gulf.

Surveys Being Made

The Service is undertaking a reconnaissance survey of the Ohio Valley to determine the amount of sediment laid down by flood waters both in urban areas and on the river flood plain. Work on the urban areas was begun as soon as receding flood waters made the cities accessible. A field party of the Section of Sedimentation Studies, Division of Research, is making measurements and collecting samples of sediment in the 10 largest cities or metropolitan districts between Pittsburgh and Cairo. Reconnaissance surveys of the flood plain areas will be started by a field party of the Section of Conservation Surveys, Division of Operations, as soon as the bottom lands are drained sufficiently to permit access.

In the cities, thickness measurements of the sediment—mostly very fine silt, but occasionally very fine sand—are being so spaced as to give a basis for computing representative averages for various sections and then totals for the cities as a whole. A record is made of the apparent degree of dryness of sediment at each point of measurement. Numerous samples are being collected and sealed in glass bottles for moisture determinations. From these the dry weight and volume of sediment will be calculated. Measurements are being proportioned roughly between streets, yards, and building interiors.

Estimates Given

At the time this is written (Feb. 14), the reconnaissance of cities is about half completed. No computa-

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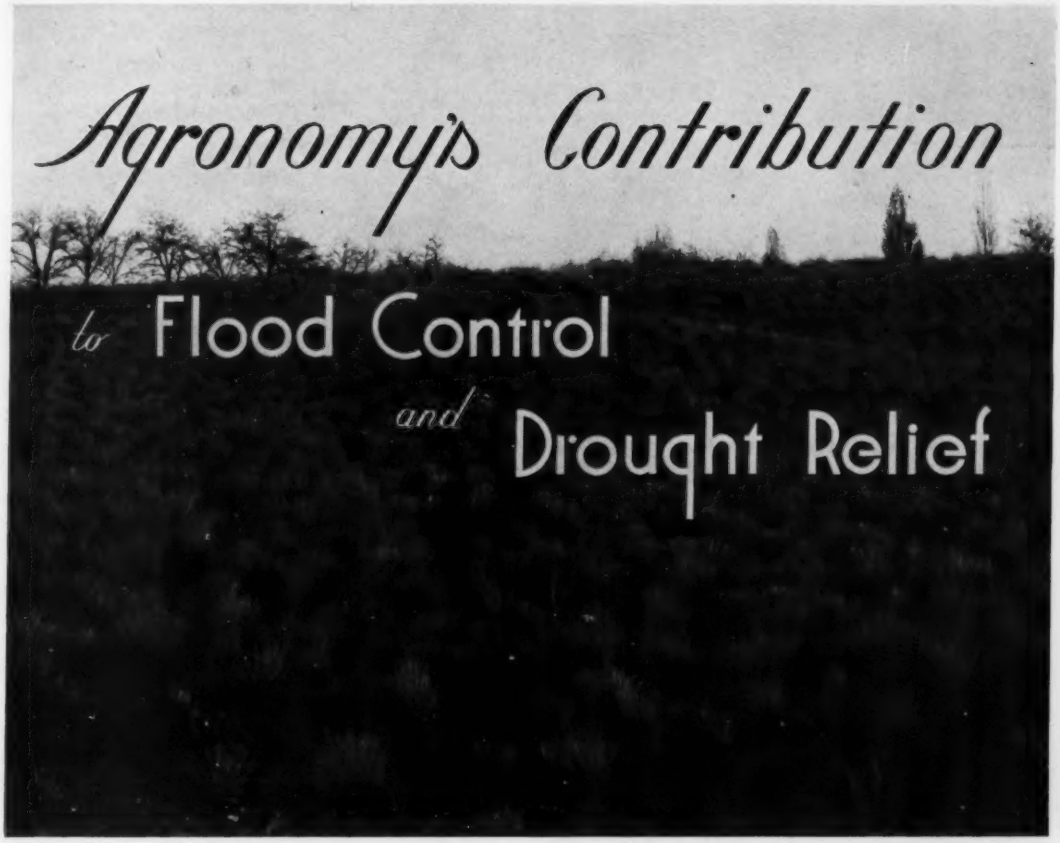

By C. R. Enlow [1]

FARMERS will generally tell you that a soil recently broken from sod shows very little sign of erosion. Experiments at soil conservation stations indicate that soils naturally high in organic content, or to which organic matter has been added, allow three to four times the infiltration of moisture that is allowed by the same soils depleted of organic matter and badly eroded. Severe wind erosion in the Great Plains did not take place until the organic matter in the soil had been greatly reduced by tillage and cropping.

When we first started to farm in this country, which was only a short time ago as compared with the length of the period covered by the world's agriculture, our soils were very high in organic matter. We felt, apparently, that the organic content of the soil was inexhaustible, judging by the farming practices that we followed and are still following to a large extent. These practices will be continued until it is generally realized that something must be done to maintain and improve the soil. Production of crops, tillage methods, erosion, leaching, and other factors caused by man's disturbance of the soil lower its fertility and organic content.

Organic Matter Must Be Restored

A program to conserve soil and water in cultivated fields and on pastures is principally one of maintaining or improving the organic content and fertility. Our fields were originally laid out without thought of preventing erosion. The practice of tillage across the slope was due at the beginning to the difficulty of pulling machinery up and down. Very little, if any, conscious attention was given to maintaining cover on the land throughout the year to prevent the soil washing away. Very little effort was devoted to the return of organic material lost through years of cultivation. No thought, apparently, was given to the necessity of maintaining the fertility of pasture lands in humid sections or to conserving the moisture

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Contour ridges in pastures have been used extensively in Texas. This picture was taken immediately after a 3-day rain totaling 18 inches, and the ridges were not damaged. Contour ridges on slopes greater than 5 percent have not proved effective in spreading the water over the area between ridges, to allow absorption. On slopes up to 2 percent they were completely effective in holding and distributing rainfall. Efficiency decreases as the degree of slope increases.

in semiarid pasture or range lands. Our grazing lands were regarded as a permanent source of income and only in the past few years have farmers in general recognized that formerly good pastures are now weed patches, badly eroded, and neglected.

The agronomists and range men of the Service can aid materially in minimizing flood hazards by encouraging a program to maintain good vegetative cover throughout the year, insofar as this is allowed by the prevailing system of farming. The production of green manure crops, both winter and summer, thus increasing the soil's organic content and its moisture-holding capacity, should be pushed vigorously. Contour cultivation must be encouraged, as this prevents the water from following ready-made channels such

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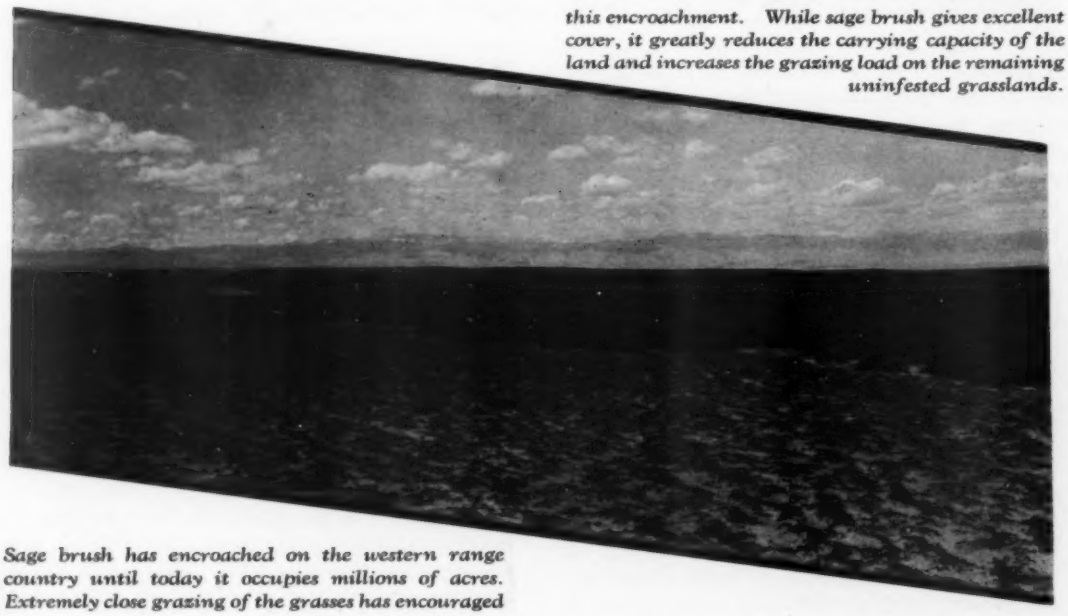

Sage brush has encroached on the western range country until today it occupies millions of acres. Extremely close grazing of the grasses has encouraged this encroachment. While sage brush gives excellent cover, it greatly reduces the carrying capacity of the land and increases the grazing load on the remaining uninfested grasslands.

SILTING DID NOT DISCOURAGE THIS PLANT

By Evan L. Flory [1]

IN THE cut bank of an arroyo through an alluvial plain water and wind have exposed the root system of a sacaton plant (*Sporobolus wrightii*). In the picture at the left, the lowest dart, 6 ½ feet below the present surface, indicates an old soil surface. This surface was heavily vegetated, as indicated by the layer of rich black soil. Shortly before the first deposition of 8 inches the area was swept by fire as shown by the charred stems. What caused the deposition of silt is merely a matter of conjecture, but it is quite possible that the destruction of the cover by fire was responsible.

Burning and covering, however, were not sufficient to daunt the sturdy sacaton plant, as it was able to survive the covering and firmly established itself on the new surface. That it was the same plant could be readily observed by vestigial connective stems and roots.

At the right is a closer detail of another plant on the same level which shows the course of connection nearly to the present surface. Such connections are not so apparent in the first picture, but they were readily traced in the field to the two surviving plants shown on top of the bank. These two plants have survived three fires on the three lower soil surfaces indicated by the lower three darts. Six successive silt deposits of 9, 10, 26, 8, 8.5, and 14 inches, totaling 6.5 feet, failed to exterminate this plant. With the first and second covering the number of plants apparently increased because of the spreading top which continued to grow. The third and deepest deposition of 26 inches smothered most of the plants but a few were still able to survive.

How long a period has elapsed in this process is difficult to imagine, but at least three of the soil surfaces persisted long enough for fairly distinct zones of black earth to be formed. In a semiarid climate where the temperatures are high, evaporation high and rainfall less than 9 inches yearly, the formation of such humus layers could very possibly take several hundred years.

[1] Associate soil conservationist, Albuquerque. N. Mex.

FERTILE VALLEYS laid waste by Upland Erosion.

By Stafford C. Happ [1]

SEDIMENTATION in streams and valleys is a widespread natural process which rarely attracts the attention that its importance deserves. Running water tends to pick up sediment wherever soil and subsoil materials are exposed, and to drop this load farther downstream. The waters which carry and deposit the sediment catch the public eye, especially during floods, but the sediments themselves, even when exposed by receding waters, are soon lost to the casual view. Silt deposited in city areas by flood waters receives some attention, for it must be removed from streets, cellars, and buildings, but the vaster accumulations in valleys is given comparatively little consideration. Such deposits, as a matter of fact, frequently are regarded favorably because of their reported value in maintaining the fertility of such lands as the Mississippi Delta and the Nile Valley of Egypt.

Sediments consisting of sand and gravel are the more conspicuous, particularly when they block highways or railways, but even these are too often thought of as comparatively minor and incidental aspects of flood damage.

Reaching the Subsoil

Under conditions in modern, civilized countries stream and valley sedimentation becomes serious indeed. As a result of accelerated erosion of cultivated sloping lands from which the forests have been cleared, or of overgrazed range lands, the original fertile topsoils disappear down the streams toward the seal More and more infertile and coarse subsoil materials then are carried into the streams by rain wash. The character of the sediment being deposited in and along the main streams thus gradually changes for the worse. Smaller and smaller proportions of plant-food material are included in the sediments periodically spread across the major valley bottoms by flood waters, and in extreme cases fertile valley soils are buried beneath sand and gravel.

As the sediment load carried by the rivers increases in quantity and in coarseness, the channels begin to fill and flood dangers grow worse. With the choking of drainage ways, bottom lands become water-logged and swampy, making cultivation unprofitable and often killing valuable timber. Dredged drainage canals are filled, and artificial levees are overtopped by flood waters as stream channels are built higher by deposition on their beds. Thus, obvious damage to costly improvements and property, and even danger to human life, is added to the more general but less conspicuous process of impoverishment of fertile valley lands.

The Soil Conservation Service is concerned with stream and valley sedimentation, both as a downstream effect of accelerated upland erosion, and because of the direct damage to major valley soils. Preliminary field work to obtain basic data on the problems and processes involved was begun late in 1935 by the Section of Sedimentation Studies, Division of Research. Since this is virtually a new and almost

[1] Project leader, Stream and Valley Investigations, Section of Sedimentation Studies, Division of Research, Soil Conservation Service.

1. Typical view of the badly sanded East Goose Creek drainage canal, in the Wells District.

2. Looking downstream from the head of the "sand plug" in East Goose Creek canal, about 1½ miles below site of picture 3.

3. Comparison in growth of cotton on sanded and unsanded parts of same field, such as occurs when sand is being spread across fields still kept in cultivation.

4. View of field partly abandoned to briers and willows, taken a few hundred feet from picture 1.

5. Raw sand spread among willow trees which have grown up in field abandoned about 10 years ago. This view is along West Goose Creek, near the head of a "plug" similar to that in picture 4.

6. Typically gullied old field in the Wells District abandoned about 10 years ago.

unknown field of investigation, attention has been directed chiefly to development of detailed research plans and methods of study. However, much significant information has already accrued. In the Wells drainage district in Lafayette County, northern Mississippi, for example, the data are revelatory of conditions which obtain in one of the areas investigated.

In 1920 about $30,000 was spent for construction of drainage canals in the Wells district, which includes

some 2,000 acres of bottom land on Tobitubby Creek. The district drainage commissioners originally estimated that these expenditures would produce benefits amounting to about $54,000. The work was financed by a $27,000 bond issue which was to have been retired by taxes totaling about $55,000, to be collected over a period of 23 years ending in 1943. Before the completion of the construction work it was found necessary to issue an additional $11,000 worth of bonds which would have increased the total cost to more than $71,000, but owing to legal complications the taxes assessed to cover this additional cost are not being collected.

Clogging of Channels

The need for drainage was due mainly to the clogging of stream channels by sand washed from gullies in the tributary uplands. However, the plans did not include any treatment of these sources of the trouble. Sand continued to wash from the gullies, and collected rapidly in the new drainage canals. Within 5 years, according to reports of local residents, the canals had ceased to function adequately. In 1927 the board of drainage commissioners of Lafayette County inspected the district and reported that work was needed to reopen the canals, but no funds were available for the purpose. Today, three-quarters of the canals are completely filled, and in many places are recognizable only as low ridges of sand. Because of the retarding effect of trees and brush along the banks, sand has been piled up in the channel in places nearly 2 feet above the level of the adjacent ground surface. The depth of channel filling has been found, by test borings, to be consistently greater than the original 8-foot depth of the canal. The surrounding ground surface has likewise been covered with sand deposits, to an average depth of at least several feet throughout the district.

Most of the remaining sections of the canals are so badly filled that they cannot provide adequate drainage. Filling apparently proceeds chiefly by upstream growth of a "plug" of sand. At the head of the section completely "plugged", the waters spread overbank, and drain down the valley through back swamps between the canal line and the valley sides. Considerable standing timber has already been killed by the rising ground water table in these back swamp areas, and they are totally useless for farming. At the head of the plug, and to a lessening degree from there upstream, frequent floods carry sand overbank and spread it across the valley bottoms. A little of this sand improves the soil texture, but unfortunately the accumulation generally continues much beyond this stage.

This process of sanding of the bottoms began long before construction of the canals, for it was described as early as 1860 by Dr. E. W. Hilgard, then State geologist. Local acceleration of erosion proceeding headward from the artificial ditches has been a contributing but not a principal cause of the excessive erosion and sedimentation. The ditches may have caused the area of most serious damage to be extended somewhat downstream, but at least most of the district apparently was doomed by the gullying of the upland, regardless of the drainage ditches. Of the present sand deposits outside the channels, which have been found to range in depth to about 10 feet, perhaps half may have accumulated before the canals were dug. Filling of the Wells drainage canals has been only an incidental feature in a century-long period of accelerated sedimentation, but the rate of valley filling was increased by opening of the canals. Because of the deposition of sand across the valley fields, many of these have been abandoned to brushy swamp lands and willow thickets, and during the past 10 years have yielded practically no revenue toward payment of the cost of the project. On one of the three main canals (East Goose Creek) complete filling of the channel progressed headward 1,650 feet between March 27, 1936, and February 2, 1937. Computed on the basis of average cost of the canals, including interest charges, this represents a $2,000 loss. For the canals of the 2,000-acre district, it is estimated that the destruction of invested values is now going on at a rate of at least $500 per month, exclusive of the loss in productive capacity of the fields served by these canals. Yet the taxes will continue, at least until 1943, to pay for canals already three-quarters buried in sand.

Causes of Sanding

The uplands surrounding the Wells district are covered with a brown silt loam of high fertility. Soon after the region was settled, about 1835, this brown loam soil became the basis of a prosperous agriculture. The upland soil was unusually well adapted to growing cotton, which has always been the important cash crop. On the other hand, the bottom lands along the creeks have always been preferred for corn, the staple food and feed crop of the country.

Once the forests were cleared, accelerated erosion began and quickly became a serious problem. The average annual rainfall is over 50 inches, and moderate

to rather steep slopes are prevalent. The region is physiographically almost fully mature, with local relief of 100 to 200 feet. Under such conditions, rainwash erosion soon began taking a heavy toll of the soil. The erosion problem was accentuated by the common practice of "turning out" land which has begun to decline in production, while clearing other new fields. No effort was usually made to protect the "turned out" fields, and these became the prey of spreading and deepening gully systems.

The gullying has been especially serious because of the geological conditions. The district is in the Coastal Plain region and is underlain by the Eocene Holly Springs formation, which is largely composed of unconsolidated silty fine sands. The upper few feet of this sand is a reddish, oxidized, partly cemented zone (formerly considered part of the Lafayette formation) over which the brown silt loam is only 2 to 5 feet thick. Once the brown loam is washed off, the red Lafayette sand begins to be carried into the streams. Under primeval conditions the streams had adjusted their gradients to forested conditions when the sediment load was dominantly silt. These well-graded streams are not steep enough to carry much sand, and hence the sand accumulates in the channels. When further deepening of the gullies exposes the bedrock sands, the conditions become even worse. These unconsolidated sands erode very rapidly, largely by undercutting, and once they are exposed, gully control is very difficult.

Recent Cycle of Cutting

A significant factor in the situation has been the development of a system of arroyos trenching the headwater parts of the valleys. The term "arroyo" has not generally been applied to these incised, steep-walled, flat-bottomed, channels in which water flows only intermittently, but they are in every way similar to the typical "arroyos" of the Southwest. They reach a depth of 12 feet, and a width of 50 feet. The arroyo development has been a serious part of the erosional damage, both by the direct removal of cultivated valley land through growth of the arroyos, and by lowering the water table in periods of drought. The arroyos have also played an important part in the valley sedimentation, because their growth has added considerable quantities of sediment to the load of the streams farther down, and because they serve to carry vast quantities of sand and silt downstream from the gullies to the larger valley bottoms. If it were not for the arroyo channels much more of this sediment would have remained in the narrower and less valuable headwater parts of the valleys.

These arroyos have had a complex history, for in many places they are undergoing filling by accumulation of sand in the bottom of the channels. In places this sedimentation has gone so far that former arroyo channels are now completely filled with sand. In such cases, the process has apparently been essentially one of back filling, extending headward from the sanded valley bottoms at the arroyo mouths. Elsewhere the usual arroyo cycle, of deepening followed by widening, has been interrupted by a new period of down-cutting, so that small scrolls of flood plain, supporting trees at least 20 years old, occur within the main arroyo walls. These old flood plain remnants suggest a period of partial stabilization following an earlier cycle of excessive erosion. Numerous old, wooded, and largely stabilized gullies which occur in the region may likewise date from this earlier period of excessive erosion. According to opinion and report, such a period occurred as a result of abandonment of many fields during and just after the Civil War.

Stream Bank Erosion

Below the arroyos the intermittent streams have flat-bottomed, sanded, shallow channels. At least part of them have developed by filling of former incised channels of the arroyo type. As the streams which flow in wet weather are unable to transport all of the sand entering them from the gullies, the gradual accumulation of sand causes the beds to be built up. This ordinarily produces a tendency for a widening of the channel by lateral erosion of the banks, with resulting destruction of the bordering fields. In places where this form of erosion has been particularly severe, the channels have been widened to several times their usual width. Lateral erosion is most active on the stream beds, which migrate sideward and downstream by undercutting of the bank on the outer side of the bends.

Bank erosion has sometimes been inadvertently aggravated by cutting off the trees and brush which line the stream banks. This is usually done to reduce the length of periods of overbank flooding, by increasing the rate of flow in the channel. In one of the most striking instances observed in the Wells district, an attempt to obtain better drainage was made a few years ago by clearing the banks along the upper part of one of the canals. Today, this section is 35 to 40 feet wide where it was cleared, but the canal is only 15 to 20 feet wide for more than a mile downstream from the

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quarter-mile section which was cleared. Above the cleared section the channel is even narrower. Over half an acre of the bordering bottom-land fields have been washed away in this one small section, due to the bank clearing.

Principles Hold Elsewhere

The history of the Wells district emphasizes the futility of attempting control of drainage and sedimentation problems without consideration of the upland erosion which is the fundamental cause. Because of the exceptionally severe upland erosion and the proximity of the district to the areas of most active gullying, the economic loss has been rapid and complete. The principles involved, however, are of much wider applicability, and deserve consideration of all agencies concerned in similar developments. Some erosion-control work has been done in the watershed by the Soil Conservation Service during the past 3 years, but much more will be required before there can be any hope of successfully reclaiming the bottom lands now swamped and sanded.

There is, however, another and perhaps equally important lesson to be learned here. It is obvious that some addition of sand to the prevailing heavy bottom-land soils is decidedly advantageous in improving the soil texture. Large quantities of sand are now in progress of transportation by the streams, and stored in the filled canals. Farther downstream are wide valley bottoms which would undoubtedly profit by some addition of sand to the heavy soil, provided adequate flood control and drainage could be established and maintained. Diversion of the sand across these bottoms would aid in preventing the choking of major stream channels by sedimentation farther downstream.

Conclusion

Thus, there is need and opportunity for improvement of the valleys, by some direct attention to the problems and processes of stream transportation and sedimentation. There appears to be a reasonable opportunity for combining conservation of upland soils with reclamation of valley lands. Much of the sand entering the valleys comes from gullying of the least valuable parts of the cultivated uplands, so that considerable economic improvement might be obtained by a readjustment of the present land-use practices.

From Farm Fields to City Streets

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tions have been made and no moisture determinations have been run on the samples. Therefore, I feel very reluctant to hazard an estimate on the amount of sediment that has been deposited in the cities. Nevertheless, by roughly scaling the flood areas of the principal cities and averaging the recorded measurements, assigning a probable weight per cubic foot based on the apparent degree of dryness recorded at time of sampling, some round figures can be obtained that should be within the order of magnitude, even though moisture determinations may finally change them as much as 50 percent.

These preliminary estimates are for the flooded areas and the amount of sediment, dry weight, deposited within boundaries of the following cities:

Cities	Area flooded	Amount of sediment
	Acres	*Tons*
Wheeling, W. Va.	2,145	130,000
Huntington, W. Va.	5,780	215,000
Marietta, Ohio	1,152	110,000
Portsmouth, Ohio	3,060	100,000
Cincinnati, Ohio (metropolitan area)	[1] 12,800	500,000

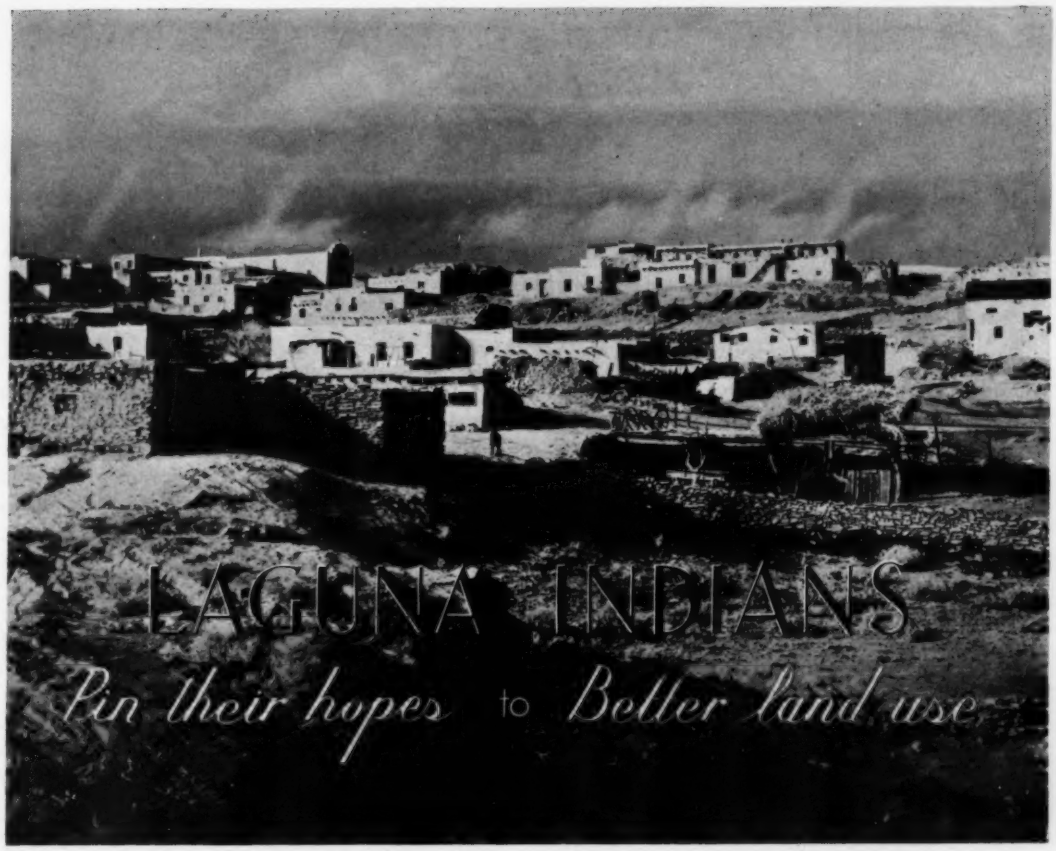
[1] Approximate.

The cost of clean-up work directly attributable to mud left in the cities will run into millions. The city engineer of Wheeling, W. Va., stated that after the flood in 1936, it took 1,500 men and 50 trucks 8 weeks to remove the mud and debris from Wheeling.

Looking at the situation in the flooded cities as a whole, it seems that conditions might be summed up thus: Millions of tons of soil lost in a single fortnight from lands that cannot afford it. Millions of tons of soil deposited in cities that don't want it. Millions of hours of labor spent in ridding cities of it. How much could we afford to spend to keep the soil where it ought to stay—or rather, how long can we afford not to?

In Region 11 more than 1,600 acres of waterways on agricultural land have been seeded and sodded by the Service. This treatment will prevent these areas from developing into gullies.

Although it is difficult to place a definite value on the utilization of crop residues, cooperating farmers in the Northwest estimate the gains from this practice at from $5 to $10 per acre, due to the prevention of soil losses.



By Richard L. Boke

IN THE seventeenth century a small group of Indians broke off from the Pueblo of Acoma to establish a new village of their own, now known as the Pueblo of Laguna, on the tributary of the Rio Grande. Today the colony numbers 2,200, with seven compact rock and adobe villages scattered over 237,000 acres of tribal land. These Indians have become prosperous farmers, perhaps the most successful of the Indian stock raisers in the Southwest. The little flock of sheep which they brought with them now numbers 48,000.

As the pueblo grew and the herds increased, the land lost its thick cover of sacaton grass. From the valleys to the mesa top browse has become thinner, and erosion has ensued on every hillside.

Reaching Out for More Land

In order to keep his bands of sheep, the Laguna Indian has been forced to rely upon the grass, water, and soil outside his own area. He has leased and homesteaded more and more land, and has taken advantage of the great Spanish land grants scattered along the Rio Grande and its tributaries. But wherever he has gone it has become increasingly difficult to obtain sufficient grass and water for his flocks. He has noted the damage with dismay.

So clearly did he realize the situation that when the Soil Conservation Service in cooperation with the Indian Service came along in 1935 and told him that his land was overgrazed, his flocks were too large for his resources, and his children's land heritage endangered, he readily agreed to a 4-year reduction program. Under this he would reduce his flocks to the carrying capacity of the land. At the same time the Soil Conservation Service was carrying on an erosion-control program on the B. M. Montano area, an old Spanish grant of 44,000 acres which had come under the administration of the Federal Government through purchase.

Laguna herder and sheep on severely overgrazed area.

On the basis of surveys, the Service estimated that this grant would carry at the outset 3,000 head of sheep for 7 months out of the year and still improve in grass cover and erosion control if the sheep were properly herded and managed. To help out the Laguna Indian in his reduction program, the two Government agencies told him that he could graze 3,000 head of his sheep in 1935 and 1936 on the Montano grant. With this 3,000 the grant was properly used for the first time in many years. There is an abundance of forage under the better management system. There was less damage to the plants by trampling and congestion. The sheep were not kept thin by constant traveling in search of food. The Laguna lamb crop on this properly used area was over 95 percent, while for the same kind of sheep managed in the old way, it was only 65 percent. Each of the sheep wintered on the grant averaged a pound of wool more than those wintered on overused areas. The price obtained for the wool clipped from the sheep on the Montano grant was 23 cents per pound, while that for the same kind of sheep on depleted lands was 21 cents. The wool from sheep clipped on the grant was worth $1.60 per head, while that from the others was worth only $1.26.

Increased Returns

During the summer of 1936 the grant was not grazed, but was given a rest until August. Then 1,000 ewes with their lambs were returned to the area. At the time of marketing, the lambs from this flock overaged 64 pounds and sold at the rate of 7.25 cents per pound, while the lambs from the same kind of ewes raised on depleted areas averaged 47 pounds in weight and sold at the rate of 5 cents per pound. So in 1 year the forage on the Montano grant, due to proper use and proper management, made a difference in revenue of $2.25 per lamb.

On the ranges of the Southwest, erosion control depends fundamentally on proper use. The Laguna Indian has seen that less erosion and more grass and better sheep go together. In better land use lies the future of his agriculture and livestock, and therefore of his villages.

Agronomy's Contribution

(*Continued from p. 192*)

as are made by up-and-down hill tillage. The use of tillage implements that will provide for holding the water on the land should be encouraged.

On the millions of acres of pasture land, mismanaged for so many years, the program is naturally one of increasing the quantity and quality of vegetation. A heavy growth of grass offers excellent flood control because it minimizes the run-off. Pasture land, depleted of fertility, cannot be expected to produce a heavy growth of grass, particularly if it is continuously heavily grazed.

To reestablish good cover on pastures and ranges, it is necessary first to conserve the water that falls so that it can be utilized by the vegetation. This can be accomplished in large measure by the construction of contour furrows. Thousands of instances of the usefulness of contour furrows for this purpose are now in evidence throughout the country. Contour furrows, except in those regions where the lack of moisture is the only factor involved, cannot, however, make grass grow. There must be enough plant food in the soil to produce grass plants and this can be supplied in the form of fertilizer. Grazing practices, in most cases, must be changed, as grasses cannot stand continuous season-long grazing, year after year; they require an opportunity to store reserve food and to develop strong root systems capable of producing a dense growth in competition with less desirable vegetation.

(*Continued on p. 214*)

WEIGHING THE COSTS OF FLOOD CONTROL

By Walter J. Roth [1]

THE cost of floods in general may be computed in terms of the dollar value of damage to municipal and industrial property ranging from the dwelling and goods of the humblest householder to the property of the largest corporation. It will include damages to highways, bridges, railroads, communication lines, water supply, and like items; to agricultural property including farm buildings and lands, crops, pasture, livestock, forests, and wildlife.

The Task of Appraisal

Important in connection with the damage to property is the cost of the replacement and repair, of cleaning up, and of rehabilitation. Appraisals of this sort are relatively simple. Somewhat more difficult of appraisal but ranking as real costs nevertheless are the losses due to the interruption of activities of all kinds—factories, commerce, communication—and the loss of market connections, all of which result in a loss of income. Most difficult of appraisal but of extreme importance because of the many individuals involved and because of its poignant effect is the human suffering, the anxiety, the strain, the privation, the sickness, and often the loss of life. The appraisal of these costs is a difficult task calling for the best judgment of the engineer and appraiser alike; but it can be done.

Loss of Fertility

A phase of the cost of floods probably overlooked but very important from both the private and the national point of view is the loss of fertility and productive capacity because of erosion on tilled farm lands through soil removal from higher areas with subsequent redeposition on lower areas and in channels, ditches, lakes, and reservoirs. The damage is not alone to be measured in terms of the immediate loss to the farm or farms involved, but is to be measured also in terms of the lowered community productivity and declining income with the inevitable consequence of depopulation and economic and social disintegration.

As already intimated, the estimate of the cost of floods will vary depending upon their frequency, their intensity and duration. The frequency of floods, we are assured, can be decreased through appropriate and integrated means of control. Likewise, the intensity or duration can be modified. These concepts will be treated somewhat more fully in the paragraphs which follow.

The estimate of the cost of control is affected by the degree of control contemplated. Not only would complete control be more costly than partial control, but as efficiency advanced, costs would be accelerated. The question confronting us is not so much "Will it pay to control floods?" but rather "How far is it good business to attempt to control floods?"

The cost of control contemplated then hinges upon an appraisal of the engineering and other works deemed necessary to catch, hold, and drain off the expected precipitation. Whether these works be dams, levees, revetments, spillways or whatever type need not concern us here. It is sufficient for our purpose to point out the considerations lying behind the choice of the alternatives before us as individuals and as a nation.

Soil and Water Conservation

In consideration of the particular type of control to be adopted, serious thought should be given to the part which can be played in a program of flood control by the area-wide inauguration of appropriate soil- and water-conservation practices. Next to the oceans the soil represents the greatest natural water storage reservoir available to us. For much rain water which now runs off from the nonreceptive fields and farms to swell the streams to flood stage, the soil if appropriately treated could act as a "catch basin" and "delayed-delivery works", feeding the streams over a long period of time rather than in short, sharp, flood-inducing fashion. In this manner the minor flood crests could be reduced and their frequency decreased.

For heavier rains and rains of longer duration and volume now causing the "super-floods", even a complete soil- and water-conservation program cannot be entirely effective. However, this soil storage, coupled with appropriate land-use methods and properly designed channels on farm lands, can be expected to deliver the actual run-off in somewhat delayed fashion instead of the present pell-mell catapulting of excessive run-off into existing inadequate drainage systems. It is conceivable that in this manner even the larger floods could be affected though, obviously, in less proportionate degree.

(Continued on p. 207)

[1] The author is head of the Section of Economics of Soil Conservation, Division of Research, Washington, D. C.

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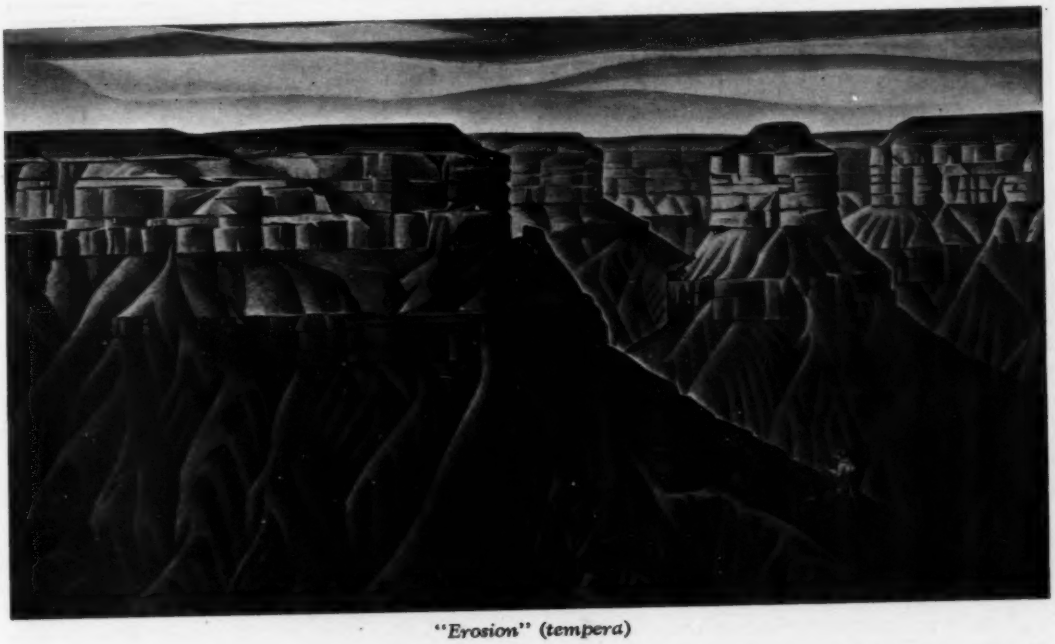
The TRAGEDY of WIND EROSION

ON THIS and the opposite page are reproductions of three much-discussed canvases by the distinguished artist Alexandre Hogue.

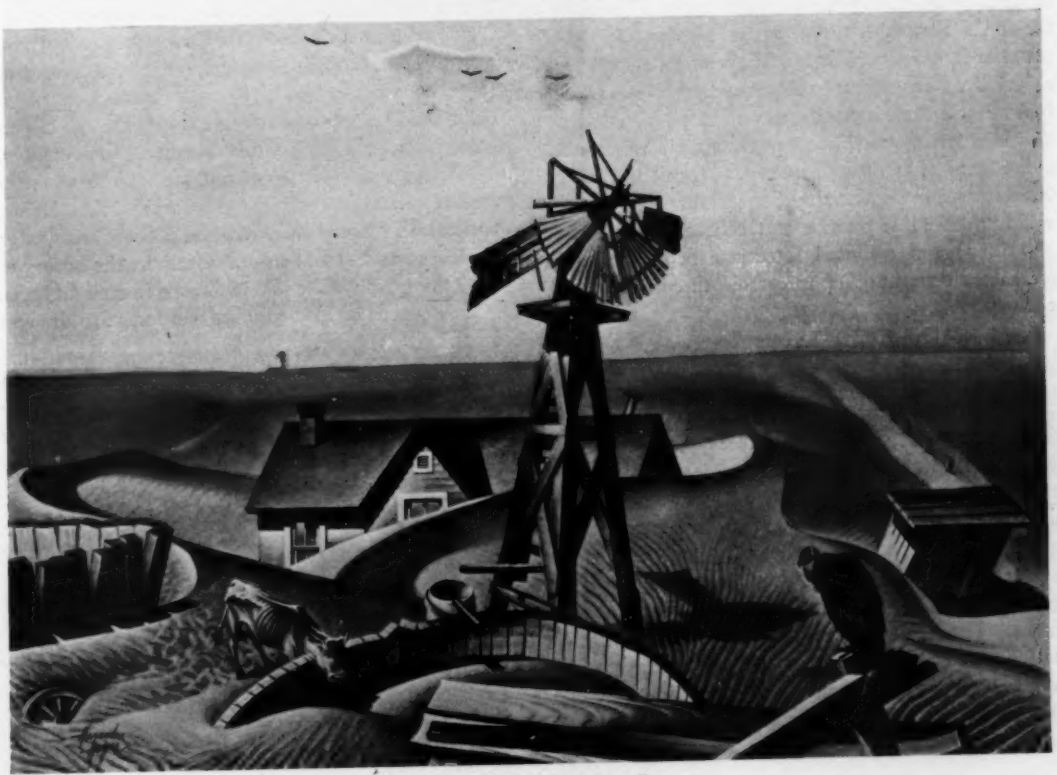
The artist spent many years on a ranch near Dalhart, in the Texas Panhandle. His windmills ought to work, because of his personal experience in pulling sucker rods and pump pipes and replacing sections in the wheels. He calls himself a genuine "dust eater", saw the plow rip through fine garden patches and feed crops to prepare the land for wheat empires and eventual erosion. He favors the spelling "drouth" because it has an "earthy dryness" and is more easily pronounced.

"Dust Bowl" appeared in a special edition of *London Studio* recently. This and companion pictures have hung in the Whitney Museum, the Boyer Galleries, and the First National Exhibition of American Art, in New York City; the Corcoran Gallery of Art, in Washington, D. C.; the Chicago Art Institute.

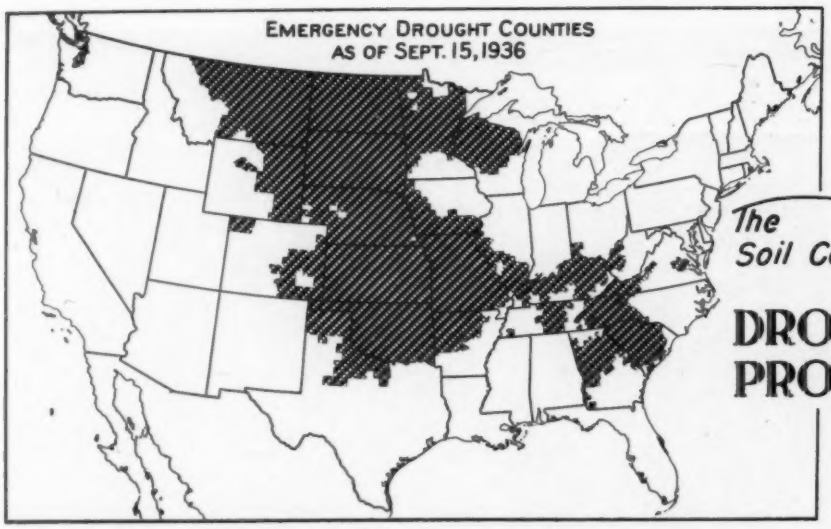
"Dust Bowl"



"*Erosion*" (*tempera*)



"*Drouth-Stricken Area*"



The Soil Conservation Service DROUGHT PROGRAM of 1936

By-W.F. Peel, Division of Operations

ON JULY 7, 1936, 97 counties were designated by the Department of Agriculture Drought Relief Committee as "emergency drought counties", and by the end of November this figure had increased to 1,194 counties located in 24 states. The program for relief as based on reports and recommendations of various Federal and State agencies served as a guide for all Government commissions in providing aid to farmers in drought-stricken areas. Because of the nature of the work of the Soil Conservation Service, that organization was in a favorable position to take over many of the obligations and technical directions necessary to a workable drought-relief program throughout the country.

Benefits to Large Acreage

The work of the Service has been concentrated chiefly in the most seriously affected areas in the Plains States and the regions east of the Mississippi River, with the result that approximately 2,900 erosion-control projects have been established. The acreage benefited is in excess of 1,430,000, and employment was given to 17,000 persons. Relief funds provided farmers with a source of income with which to purchase emergency rations and continue the operation of their farms. Through experience gained by taking an active part in the work program, the farmers will be able to carry out on their own farms the soil- and water-conservation practices made available to them by technicians.

A few of the major features of the program as established by the Committee will serve to show the main factors considered in determining the work areas:

1. Application to Interstate Commerce Commission for reduction of railroad freight rates for shipment of stock to more productive areas. Reduction of as much as 85 percent on outbound shipments and 15 percent on returned shipments of livestock were obtained.

2. Inauguration of a seed-purchase program whereby limited varieties of wheat, durum wheat, oats, barley, and flax, all adapted for growing in drought areas, were purchased and stored in granaries. In the spring of 1937 this grain will be sold to farmers in drought areas.

3. Shipment of food supplies and forage to drought areas.

4. Institution of a cattle-buying program in stricken grazing areas. Cattle were liquidated because of reduced supplies of forage and water. In most cases only a few milk cows and work horses were retained.

The work of the Service was to provide supervision, labor, tools, materials, and technical guidance in developing soil- and moisture-conservation practices on drought-stricken farms. In all sections of the United States which were designated for drought relief, the Service programs were so planned as to meet the individual requirements of the counties. The national program included the construction of dams, development of springs, surveying of contour lines, laying out of terraces, contour strip cropping, contour furrowing, gully control, approved rotations, establishment of erosion-resisting crops, the conversion of cultivated lands to permanent grasslands, terracing, lime-grinding, planting of winter cover crops, cleaning of streams and drifted fence rows. Cultivated fields were laid out in 10- and 20-rod strips at right angles to the prevailing winds. Shelterbelts were cleared of dead and fallen trees and brush. Protective belts of trees and wild game plantings were established in favorable locations, and abandoned rangeland was reseeded. Reports from two States indicate that approximately 70,000 tons of limestone were utilized, and of this amount the Soil Conservation Service ground 40,639 tons and burned 18,750 tons.

In the western area where whole States were designated for emergency drought relief, the situation called for the development of a water-conservation program of considerable extent. This included the construction of dams supplemented with dikes for water-spreading purposes. The construction of reservoirs for stock-water was fostered; and where possible, these dams were placed in strategic locations where they might serve the dual purpose of stock supply and flood irrigation. Reservoirs for stock watering were also located on stock trails, and it is expected that these will prove of great benefit when cattle are driven to shipping points.

Some dams were built for the purpose of benefiting groups of neighboring stockmen, while still other smaller dams were erected on areas controlled by grazing associations. These reservoirs were suitably located to provide uniform grazing. Water troughs were built below the dams, and fences put up around the fills. This program and the depletion of stock will allow natural reseeding of forage plants and will result in better grazing conditions. In Region 9 alone, approximately 410 drought dams were constructed. Larger dams placed near towns served in a few instances as main sources of water.

It is well known that a considerable portion of our range land has been ruined beyond repair because nutritious native grasses, adapted through centuries of

ever-recurring drought, have been destroyed and the topsoil blown away, exposing the subsoil which is unsuitable for plant growth. However, on the greater part of the western range remnants of the native grasses still manage to survive. The topsoil, though thinning through wind and water erosion, is still worth saving. Through the efforts of the Soil Conservation Service and associated agencies, controlled grazing measures are being adopted. It appears likely that, after a period of time, these lands can be restored to a condition similar to that of half a century ago. For our western range, it is hoped that there will be an expansion of the policy which provides for the adaptation of the economic life to a physical situation which cannot be materially modified because of the climatic conditions.

The fact that whole States in the West were affected by drought and soil erosion has caused the Service and associated agencies to give special attention to that territory, but this does not mean that there was no drought-relief work in other sections of the country. The program was broad in scope and the work was carried out in all States designated for such relief.

The educational value of the work already accomplished in drought areas is a factor that is well worth thoughtful consideration. Farmers have had the opportunity to practice control measures as demonstrated by the Service, and if these measures are followed up over a period of years they will prove their worth in reducing the destructive effects of recurring droughts. Through these examples of the value of preventive measures, with instructions for their application to individual problems, it can be expected that voluntary use of preventive methods will be adopted. That this is probable is indicated by the requests received from interested farmers in all parts of drought areas for a continuance of the program. Although the emergency which required extra effort appears to be mitigated for the time being, a program for permanent relief should be inaugurated for the situation which is well described by Stuart Chase in his Rich Land, Poor Land as follows: "As I wrote in July 1936, a drought which has already caused a billion dollars' worth of crop damage is searing the prairies, the Great Plains and parts of the South. The area most seriously stricken is on the one hundredth meridian in the Dakotas * * * Thousands of families, their wheat burned to brown stubble a few inches high, their cattle bellowing with thirst, their very homes made uninhabitable by dust and sand have commenced a great migration. * * *

"There is no reason to suppose that the climate in the West is changing. There is every reason to suppose that for thousands of years, cycles have moved from wet to dry and back again, that it has often been

just as hot as in 1934 or 1936, but never before has so much of the original grassland been in crops and never have natural reservoirs been so depleted."

Again, as this is being written, Nature is demonstrating by flood rather than drought what tragic consequences result when man endeavors to use lands for purposes and in ways that are not in accord with meteorological climaxes. Neither extreme dearth nor prodigality of water may be prevented by human efforts, and it would seem high time to recognize this fact by planning land-use programs that can be made to cooperate with Nature.

Costs of Flood Control

(Continued from p. 201)

Further aggravating the strain put upon the present drainage system is the contribution, through the medium of flood-water torrents, of silt and sediment from farm lands. This causes shoaling and filling of channels, ditches, lakes, and reservoirs, and makes ineffective their function for drainage or storage as the case may be. A soil- and water-conservation program could function to minimize further the damages of floods by reducing this silt and sediment in our streams.

An appraisal of the cost of control, in whatever degree this be contemplated, need not be increased by the total outlays for the soil- and water-conservation practices designed to reinforce the downstream engineering program with which it is to be integrated. The reason for this statement is the value of the soil- and water-conservation program to the farmer in improving yields and increasing income. This situation need not complicate the appraisal of the cost of the control program, but it should be taken into account.

While the cost of control, or an appraisal of its cost, is complicated by reason of the many estimates involved, further complication arises from the lack of adequate information concerning floods of varying intensities. Although this information cannot be obtained on short notice, considerable data in this field and in the general field of the energetics of water and silt will be forthcoming from the researches of the appropriate sections in the Division of Research in the Soil Conservation Service. Coupled with this data, of an engineering character, are necessary studies in effective soil- and water-conserving practices, together with other allied researches, including that in the economics of soil conservation and flood control. Such studies will give us a better factual basis for appraising the degree of control which will be effective at different times, under different conditions, and for different watershed areas.

Given such factual basis for the appraisals of the costs of control, the choice between the alternatives, floods or control, can readily be made. Based upon such research the question "How far is it good business to attempt to control floods?" can be answered with a high degree of certainty. In this scheme of things the Soil Conservation Service is destined to play a significant part in research and in actual control operations.

SAND DUNES IN THE GREAT PLAINS

By C. J. Whitfield [1]

IN RECENT years, as a result of cultivation, grazing and drought, sand dunes have developed on areas throughout the southern Great Plains, more especially in the region extending from the Canadian to the Arkansas Rivers. No more striking example of the destruction of land through man-induced wind erosion has been found. Under virgin conditions the topography of this region varied from nearly level to undulating or gently rolling, with good grass cover and no evidence of dune formation.

The dunes are of two types. The first and less extensive are the "blowout dunes" which develop around wells, or from roads and cattle trails. Blowout dunes seldom reach proportions equal to those of the second type, which develop as a result of wind erosion on land which through cultivation or overgrazing has been deprived of its natural cover. Both types of dunes generally are devoid of vegetation. They should not be confused with dunes which have developed as the result of wind action on outwash materials and which usually are found to be stabilized by native vegetation.

Studies Reveal Nature of Dunes

The dunes of which special studies are now in progress are on land that never has been cultivated. The sands were blown from an adjacent 80-acre area which was cultivated from 1907 to 1914 and then used for grazing. Evidences of dune formation were first noticed in 1926, but did not appear to be alarming until 3 years later. Since 1929 striking changes have occurred, with dunes developing from low mounds to heights of 26 feet. The dunes are large mounds of sand or sandy material, ranging from 50 to 880 yards long and usually about 30 yards in width. Apparently the height depends on the age of the dune and the direction and velocity of the wind.

Wind Has Clean Sweep

The substratum of the area on which these dunes are resting is very compact and fairly level. It consists of the subsoils of uncultivated land that has been eroded by wind to various depths, in some places as much as 4 feet. The border area is an ecotone or boundary line existing between the grassland and the eroded dune lands. Because of a hummocked condition, with the mounds of loose sand devoid of vegetation, and because it displays additional characteristics which apparently aid in dune formation, this border is designated as the "critical area." Here in this border area the wind sweeps unhindered across the hard lands, picking up materials as it goes.

One of the first things observed in studying these mounds of sand was that the large dunes move very

A dense stand of Russian thistle in which the advancing dune shown in background is dissipating itself and thus rebuilding the soil between dunes. Portions of this dune were as much as 18 feet above the eroded ground.

[1] The author is soil conservationist, Division of Research, Soil Conservation Service, Dalhart, Tex.

slowly if at all—a consequence undoubtedly of their crescentic shape. It was obvious that to prepare one of these large dunes for stabilization it was necessary first to reduce its height so that the wind would carry its load of material to the hard substratum beyond. In other words, the steep slope to the leeward must be eliminated. The method used for this was as follows: An 8- by 8-inch pole, of sufficient length, was dragged along the sharp edge of the dune. One to two horses are required to draw the bottom end of the pole, and two or three should be hitched to the top end. A disk attached at the top is an aid in breaking down the steep slope. Once a dune is broken down the wind cannot form eddies and the huge quantities of sand are carried beyond to another area and there spread over the substratum.

Dunes that have become compacted, due to rains and the trampling of stock, should be disked to facilitate their movement. As a result of the application of these methods dunes were lowered as much as 15 feet in a 5-month period. Once the steep slope is broken down, the sand must be kept in condition for blowing in order that the wind may carry it away. This may be done by using, at intervals as needed, a tractor and a small caterpillar terracer. In some instances a three-row lister has been used to advantage.

Plants to Hold the Sand

To hold the sand after it has been removed from the tops of the dunes to adjacent land, the exposed substratum included in our study area was listed and planted. No row crop was secured because the season was one of drought, but a profuse growth of weeds, especially Russian thistle, developed. Protection of the area by fencing and total exclusion of livestock undoubtedly aided this weed growth, although this factor was not totally responsible as the check plot did not produce weeds to any extent. Sand blown into such treated areas is generally caught and held by the plants, and thus it is that the substratum between dunes is given the opportunity to lay down topsoil.

Land Utilization in the Area

From the standpoint of proper land utilization, or the using of the dune areas under regulated grazing, it may not be necessary or desirable to destroy completely the dunes. In the study area, dunes 8 to 10 feet in height were planted to Kafir and Milo and good stands were obtained. It appears from the studies made thus far that dune movement can be controlled by planting quick-growing, stooling varieties of grain sorghums such as 60-day maize and other crops adapted to the region. During seasons of normal precipitation it is desirable to remove the tops of the larger dunes so that they are not more than 15 feet high. Proper land use of these dune areas undoubtedly lies in controlled grazing with only a small proportion (20 percent or less) of the land in cultivation.

Among the new publications of the Service is a bulletin entitled "Blue Grama Grass for Erosion Control and Range Reseeding in the Great Plains and a Method of Obtaining Seed in Large Lots" by Jess L. Fults, associate agronomist, Soil Conservation Nurseries.

View of dunes from top of a nearby dune. The dune in the foreground is small compared with others in the group. A strip of exposed subsoil in the foreground has been listed.

FARM PONDS PASS CRITICAL TESTS

By R. W. Oberlin [1]

Water flowing from pond through emergency spillway after a heavy rainfall. Such spillways provide protection for the dams from the torrential rains common in the Upper Mississippi Valley.

AS A RESULT of the 1936 drought, considerable discussion has taken place as to the feasibility of providing an adequate water supply on farms, especially in certain areas throughout the Middle West, by the construction of earth dams and reservoirs. It is realized, of course, that such a source of supply would not be practicable in areas where the soil is of a type to permit impounded water to seep away through the subsoil. There are other large areas, however, where the subsoil is of such a nature that the infiltration rate is relatively slow, and it is on these locations that earth-dam construction is desirable.

A Representative Area

One such suitable area is that of north-central Missouri and south-central Iowa, of which the Big Creek demonstrational area is representative. This is located in Harrison County, Mo., and Ringgold and Decatur Counties, Iowa.

On this project a large number of earth dams have been built primarily as an erosion-control measure. They also serve, however, to store water and furnish a source of farm water supply. Because of the attention that this type of structure has received, a survey was made covering 47 earth dams to determine whether or not they are adequate to provide an ample supply, especially during periods of extreme drought. Ponds were selected which were known to be full prior to the beginning of the dry period, and a rather detailed survey was made just before the drought was broken, in an attempt to determine the effect of severe drought on pond water.

Storage Capacity of Ponds

As a result of this survey it was found that these ponds had a total storage capacity of approximately 2,700,000 cubic feet, or an average of 59,000 cubic feet each. Their average drainage area was 8.9 acres. At the end of the drought the 47 ponds contained 1,361,000 cubic feet of water, or approximately 29,000 cubic feet per pond, which is about one-half their total storage capacity. The drought resulted, therefore, in the loss of 1,400,000 cubic feet of water through seepage, evaporation, or stock use, and also resulted in a lowering of the water level below the bottom of the spillway an average of 2.7 feet per pond.

Year-Round Stock Water Supply

Thirty-four of the farmers in this section use the ponds as a stock water supply, the livestock totaling 1,677 head. Approximately one-third of this number use the ponds for this purpose throughout the year, while the others use them only during the summer. One man reported that his pond was his only source of water for his stock, and several said they would have been forced to sell their stock had it not been for the ponds.

In addition to the individual use of the ponds, several instances of neighbors' using them for a stock water supply were discovered. One farmer was supplying neighbors with 1,200 gallons a day, while another said that 5,000 gallons a week were being hauled from his pond.

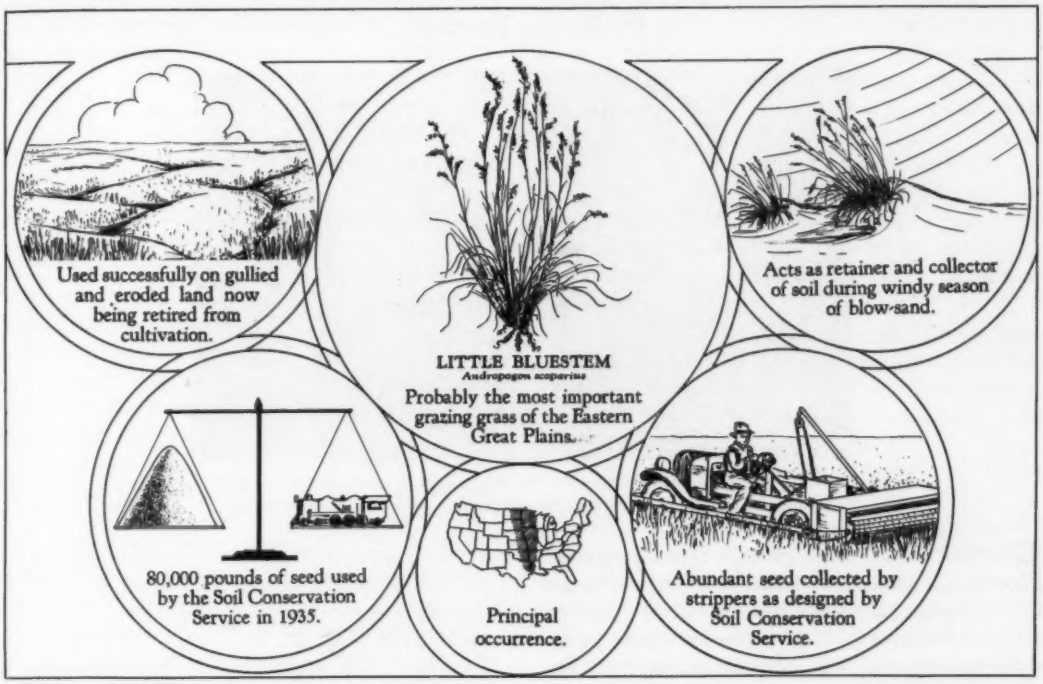
Twenty-four of the ponds are fenced to keep out stock, the fences being recommended also to protect the dams. Where a pond is fenced and used for stock water, it is advisable to insert a pipe through the base of the dam with an intake in the pond. The lower end of the pipe should be run down to a tank, and the flow of the water regulated with a float.

Ponds Have Many Uses

The ponds are an important factor in the program of wildlife conservation. Wildlife plantings have been made around 12 of them, and in 26 ponds water plants are now growing. Fish have been placed in 26 of them, and a number of farmers reported that these

[1] Regional engineer, Soil Conservation Service, Des Moines, Iowa.

LITTLE BLUESTEM FOR SOIL CONSERVATION


Used successfully on gullied and eroded land now being retired from cultivation.
LITTLE BLUESTEM
Andropogon scoparius
Probably the most important grazing grass of the Eastern Great Plains.
Acts as retainer and collector of soil during windy season of blow-sand.
80,000 pounds of seed used by the Soil Conservation Service in 1935.
Principal occurrence.
Abundant seed collected by strippers as designed by Soil Conservation Service.

bodies of impounded water are attracting wild ducks and geese.

Interesting miscellaneous uses of the ponds were noted during the survey. Two ponds had supplied ice to the farms, one farmer reporting a harvest of 40 tons. Another used his as a water supply for washing his car, while a third found his of value for the family laundry. Domestic waterfowl were seen on several ponds, and in many localities the water was used for the chickens. Almost one-third of the ponds were considered as neighborhood swimming pools, while one was used for baptismal purposes by a church in a nearby town.

Built with Trawler-Type Tractor

The ponds under discussion were built in Grundy, Shelby, and Lindley soils, all of which are particularly adapted to this type of construction. A crawler-type tractor with trail-builder attachment was used for the work which averaged approximately 1,200 cubic yards per dam. The average construction time per dam was 31 hours. The smoothing over of the dams was done by cooperators and in some instances by the C. C. C.

Remarks such as "The pond is a big help" and "This time the pond came in awfully handy" are indicative of the attitude of farmers regarding the construction of earth dams and reservoirs to provide adequate water supply on farms. Not one of the cooperators indicated that he was dissatisfied with his pond, and several said that they would like to have one or two more.

Demand for Earth Dams

As a result of this survey it can now be stated conclusively that an earth dam, properly located, constructed, and maintained in soil suitable for such construction, is a reliable source of water supply, even during periods of extreme drought. Many dams other than those included in the survey have been built, and the demand for their construction continues. The cost, compared with that of drilled wells and pumping equipment, is satisfactory. In the future a large number of these earth dams undoubtedly will be built, not only as an erosion-control measure but also as reliable sources of water supply for stock.

Retiring from cultivation all badly eroded submarginal lands and planting them to either grass or timber is an effective means of securing best land utilization.

TREES FOR CASH AND CONSERVATION[1]

By Leroy Frontz [2]

Portion of woods plot at Northwest Appalachian Soil Erosion Experiment Station from which soil and water losses were measured.

EXPERIMENT and experience have shown that ungrazed, unburned forest is an excellent conserver of soil and water. The interlacing branches and twigs break the fall of rain, lowering it more gently to the soil beneath. The roots of trees penetrate the soil to a greater depth than those of most other plants. When trees die the roots decay in the soil, leaving channels through which surface water is rapidly carried. Later much of it reappears in the form of springs. The mass of decayed and partially disintegrated leaves and twigs on the forest floor acts as a sponge, becoming saturated during wet periods and giving off moisture slowly during dry periods. The intertwining surface roots, combined with forest litter produce a condition under which it is practically impossible for soil losses or rapid run-off to take place.

The forest is the natural home of most game animals and birds. It may also furnish ample syrup, sugar, nuts, medicine, and other articles of everyday use. To a limited extent it affects the climate of the immediate vicinity. The protection and added comfort resulting to the average farm home by its presence cannot be measured in dollars and cents.

Know the Problem

Properly managed and protected woodland on the farm has a definite place in proper land use and soil and water conservation. The first step is to know the problem, a partial explanation of which is shown by economic surveys of land use in Region 3, comprising the States of Michigan, Ohio, Indiana, Kentucky, and Tennessee. The data are not to be misconstrued as argument for retiring every acre to forest.

Summaries show that of every hundred acres in farms, 11.5 acres are classed as woodland grazed and ungrazed. Ten additional acres are idle, waste, lanes, and building sites. It is estimated that an average of 3.5 acres are devoted to building sites and lanes, leaving a total of approximately 18 percent of the average farm area that is producing relatively little or no income. Further, 82 percent of the average farm area provides the necessary income to pay carrying charges and taxes on the nonincome producing portions of the farm.

Profitable, Too

Our studies have shown that in order to maintain the farm as a long-time profitable unit most of this 18 percent now classed as waste must be established and kept up in the form of well managed and protected woodland. There is but one way to accomplish this—the landowner must be shown how the woodland cover may be maintained and at the same time made to produce revenue.

Examples of farm woodlands in which some type of management has been practiced and in connection with which records of yield in forest products or money are available indicate what can usually be accomplished.

[1] Acknowledgment for data in this article is made to the following: F. D. Dean extension forester, Ohio State University Experiment Station; T. E. Shaw, extension forester, Purdue University, Lafayette, Ind.; U. S. D. A. Bulletin no. 1680, Farmers in Northern States Grow Timber as Money Crop.

[2] Forester, Soil Conservation Service, Dayton, Ohio.

Relatively speaking, the properly managed farm forest will yield an annual or periodic income comparable to or in greater amount, over a period of time, than that obtained from other crops grown on farms in Region 3.

Retired to Forest

Under the Service program, the poorest, steepest, most eroded soils on farms are those which will be retired to forest. Farm forests already existing are, for the most part, located on such areas. A study of fuel wood, lumber, and fence post prices indicates that, on a basis of a yield of one standard cord of wood or 300 board feet of saw lumber per acre per year in the region, the net income to the owner after labor and taxes are paid will be from $2 to $6 per acre per year. This net income from the woodland will continue so long as it is properly managed and protected from fire and grazing.

A study of a 25-year old black locust plantation located near Maysville, Ohio, shows a total money yield of $374.25 per acre for fence posts and fuel wood, or $14.97 gross per acre per year. Deducting for taxes, labor, and carrying charges, it is found that a net return of approximately $10 is realized.

The experience of Harvey Floyd whose farm is near Blue Rock in Muskingum County, Ohio, indicates the relationship between profitable farm operations and woodland. In 1918 Mr. Floyd purchased his farm at sheriff sale for $1,500. This farm is typical of southern Ohio land in that part of it is bottom land and the remainder relatively steep hillside. The only building on the farm at the time of purchase was a house in need of repairs and improvement. The former operators of this farm had starved out as a result of poor land management. Mr. Floyd decided that it was a waste of time and effort to attempt to cultivate the steep hillside fields. Those fields that had been cleared he seeded to pasture, and the others he retired to permanent woods. He concentrated on growing cultivated crops on the level bottom land. Lime, fertilizer, and manure were applied to the crop fields and pasture, with the result that today he is one of the most prosperous and successful farmers in his locality.

Good management and effective land use constitute the foundation of Mr. Floyd's success, but back of this highly important phase is his woodland. Even at the outset the original woodland on the farm, occupying a portion of the steeper hillsides, was put to use. Mr. Floyd rented a portable sawmill and from his woods cut sufficient lumber to build a barn, a shed, a hog pen, and a chicken house necessary to his farm business enterprise. The remainder of his lumber was sold at a profit to him of $2,000 which more than paid his original investment. The actual profit provided money for the purchase of lime and fertilizer essential to crop production.

During a period of 24 years, the 75-acre farm woods of Ami Pifer in Hancock County, Ohio, yielded from the sale of saw logs and fuel wood $11,250, or an average of $6.25 per acre per year. Value of fuel wood, fence posts, poles, and lumber used on the farm was adequate to pay for labor and carrying charges. This woods has always been protected from grazing and fire, permitting young trees to develop to replace those removed in lumbering.

The intimate relationship down through the years of the farm woods to farm business and to good land management is illustrated by the John David Groves farm near Rome, Ind. Mr. Groves' ancestors settled there in 1807 when the entire land area was covered with forest. Sufficient white oak and tulip lumber was cut to construct farm buildings. The surplus was rolled into piles and burned. Clearing proceeded for crop production on the level first and second bottoms. The hill land, amounting to about 200 acres, was kept in timber. At present approximately 373 acres in bottom land is farmed.

Prior to 1870 no thought of protection or management was given the woodland portion of the Groves farm. The woods contained a large number of beech and oak trees, producers of mast. The grazing of hogs and cattle in the woodland was a common practice. With the passage of time, however, a constantly decreasing amount of grazing has been permitted in the woodland, until today it has been practically eliminated.

Building Needs Supplied

Throughout all these years the necessary lumber, posts, and fuel wood required for the development and maintainance of the Groves farm has been secured from the farm woods. In addition, considerable money has been realized from the sale of timber products and fuel wood. There are now in use on this farm three houses, five barns, and six sheds in the construction of which about 225,000 board-feet of home-grown lumber was used.

According to Mr. Groves, the net cash value of the woodland has amounted to about $5.60 per acre per year. In addition to providing cash, the forest furnished timber and other products, thus enabling Groves to meet promptly unforeseen emergencies

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A NEW MACHINE FOR SCARIFYING TERRACE CHANNELS

By William A. Weld [1]

A SCARIFIER for use in conjunction with regular terracing equipment has been designed by the engineering staff of the Reedy Fork project in North Carolina. This attachment breaks the hard subsoil left by the grader blade simultaneously with construction of the terrace.

During the construction of terraces for erosion control, hard subsoil is often encountered and left exposed. This condition is most noticeable in the channel section of the terrace where the deepest cuts necessarily are made.

Hard Subsoil Undesirable

The smooth, hard surface of such soil, comprising a strip 8 to 12 feet wide the entire length of the terrace channel, is most undesirable for soil and water conservation, as well as for cropping.

The absorption of run-off water is greatly retarded by the impervious condition of the subsoil. It is, furthermore, most difficult to establish any type of vegetation on that portion of the terrace. Very few farmers in the Reedy Fork section have the power or equipment to break the subsoil thus left exposed.

It was to help remedy this situation that the scarifier was designed. As shown in the accompanying picture, it is mounted as a rigid attachment at the rear of the terracing machine. It can be operated very conveniently from the grader platform.

Scarifier Breaks Subsoil

A feature of this unit is that no additional rounds are necessary to accomplish the desired results. By merely lowering the scarifier, the subsoil left exposed by the grader blade is broken to a depth of 6 to 9 inches simultaneously with the back-sloping and cleaning out of the channel.

The scarifier makes it possible to establish a growth of vegetation over the entire terrace, and the water-holding capacity of the terrace is greatly increased.

This unit has proved helpful also in the construction of terrace outlet channels where vegetation is desired. By scarifying the channel bottom during the final grading operations, a very satisfactory seedbed is obtained at surprisingly low cost.

[1] Assistant agricultural engineer, region 2, Soil Conservation Service.

Scarifier attached at rear of terracing machine, thus enabling one man to operate both. Scarifier block elevated by means of lift arms to hold teeth clear of ground when not in use.

Agronomy's Contribution

(Continued from p. 200)

The advantages of deferred and rotation grazing in maintaining sufficient feed for drought periods are recognized by the farmers in some sections of the country. In the mountain valleys of West Virginia and western Virginia, for example, it is customary to allow Kentucky bluegrass pastures to make a considerable growth in the spring before stock are allowed to graze upon them. This growth of grass is generally not consumed until the dry period of the summer, usually July or August. This system of deferred grazing is one method of producing reserve food.

Lighter grazing of pastures than has been customary during the past is one protection from flood and a reserve against drought. Many of our western ranchers have learned the value of a reserve stock of feed produced during good years and stored in stacks, trench silos, and by other means. During the drought last summer, some ranchers were feeding oats and other feeds produced and stored as far back as 1932.

The agronomists and range men can contribute to both flood control and drought relief by encouraging (1) the production and storage of ample feed to relieve grazing lands in times of stress; (2) the use of proper cultural practices on tilled fields to conserve both soil and moisture; (3) the use of cover crops, strip cropping, and crop rotation; (4) proper grazing practices on permanent pastures and the production of supplemental grazing crops; (5) the use of adapted varieties of crops; and the encouragement of a well-rounded agronomic program based on proper land use that will help maintain the organic matter and the fertility.

BOOK REVIEWS AND ABSTRACTS

By Phoebe O'Neall Faris

EFFECTS OF THE GREAT DROUGHT ON THE PRAIRIES OF IOWA, NEBRASKA, AND KANSAS. By J. E. Weaver and F. W. Albertson. University of Nebraska. October 1936

The authors present in detail the results of studies made to determine the effects on vegetation of the most severe drought ever recorded in the prairies of eastern Nebraska, western Iowa, and west-central Kansas—that of 1934. The areas included 30 or more tall-grass and mixed prairies. The studies involved careful investigation as to the relationship between root depth of prairie grasses and forbs and their resistance to drying, and also examination of soils to determine available water content at various depths throughout the drought period. Lists of native grasses that entirely or almost entirely disappeared during the drought and native forbs that increased in abundance are given. Weeds which spread widely in periods of high winds are also listed.

In the tall-grass prairies it was found that while understory plants suffered great losses and in many places were entirely destroyed, some of the native grasses made decided increase in spread and growth. Wheatgrass (*Agropyron smithii*) in particular became widely established and now thrives in many places where the bluestems have died, especially in areas which had been greatly disturbed by accumulations of dust. Its vigorous growth during early spring months and its migration by long, slender rhizomes proved distinct assets for reclamation of land from which basal cover had almost or totally disappeared. Important potential centers of wheatgrass are now common on upland prairies and even more abundant on lower ground. Other native grasses showing increase as a result of extermination by drought of their taller competitors are the buffalo grass (*Bulbilis dactyloides*), blue grama (*Bouteloua gracilis*), and the 6-weeks fescue (*Festuca octoflora*).

In many areas of the tall-grass prairies, weed invasion has become a serious problem since the drought. The wild asters, catchfly, and many of the bulbous weed plants occur now in great abundance on areas which were completely or partially bared by drought and dust. Often they are the only plant species surviving over tracts of considerable size, giving the land the appearance of a series of abandoned farms.

The mixed prairies studied cover a rolling topography in west-central Kansas and border the valley of Big Creek which is a branch of the Smoky Hill River. Changes in vegetation cover as a result of drought were studied intensively by means of some 160 permanently established quadrats, as well as by observation and estimates over the whole area. An interesting series of charts included in the paper shows changes in vegetation as the result of cover by dust, soil-moisture loss, and grazing. Extensive data are given to show that little bluestem, the dominant type for the mixed prairies, suffered great losses even when protected from grazing and especially during the later periods of the drought when the reserve water in the pockets and crevices of the rocks was exhausted. This grass, handicapped by a shallow root system, suffered losses to the extent of 90 to 100 percent where it was mixed with short grasses. It was replaced to some extent by slender grama, big bluestem, and species of *Sporobolus*, but even at that much of the soil surface was left bare.

The short-grass cover which was protected from grazing during the drought displayed relatively small losses, although many forbs were either partially or completely eliminated. This resulted in an increase in the numbers of certain native forbs of greater drought resistance. In the lowlands, where soil moisture was not generally depleted until late in the period of drought, the forb population remained practically unchanged.

In the west-central part of Kansas, where drought conditions were most severe, ungrazed prairies lost 85 percent of their basal cover, moderately grazed areas 72 percent, and heavily grazed prairies 91 percent.

OUR NATURAL RESOURCES AND THEIR CONSERVATION. Edited by A. E. Parkins and J. R. Whitaker. New York and London. 1936.

This symposium, considered as a whole, presents a balanced, concrete view of the resources and conservation problems of the United States. Each of the 20 authors is a specialist in his particular field, and all write in support of the important central idea—that we must eliminate waste in the use of our soils, our waters, our forests, our metals and fuels, our wildlife, and the human life and culture of our nation. On the assumption that the remedy for waste lies in the education of all the people with regard to the genesis and nature of resources, the changes which they undergo when utilized, and practical methods which can and must be employed to offset deleterious changes, the plan of the book aims toward description of conditions as they exist today and as they point to urgent need for conservation.

The book contains a great deal of material of value to the student of soil conservation whatever may be his special field of work. The long article by Dr. Bennett, Soil Erosion and Its Prevention, in particular, points out the many and interdependent processes involved in the study of soil-erosion control. He emphasizes also the broad field for investigational work in accelerated erosion on the several thousand distinct soil types of the United States. "None too much is known about the mechanical relation of such activities as gravitational creep, sliding, fragmentation, granulation, and dispersion to processes and rates of run-off and erosion. The causative processes involved with the formation of V-shaped gullies, as distinguished from U-shaped gullies or gullies that spread faster laterally than longitudinally, have not been adequately investigated. Differential erosion on exposed sections of soil profiles characterized by markedly different horizons is a phenomenon that lies rather completely outside the knowledge of most specialists. Very little is known about the dynamics of rill washing. The baffling contrasts revealed in measurements of run-off and erosion from plots occupying the same kind of soil, the same degree of slope, and subjected to the same cultural treatments, would seem convincing evidence that the mechanics of loading and unloading on the part of thin and thick sheets of water flowing across slopes of different cross-sectional dimensions is little understood."

These special studies, and many others regarding climate and vegetation cover, must be carried out—with control of accelerated erosion definitely the goal. Tables included in Dr. Bennett's article

show soil and water losses under various crop or cultivation treatments; effect of forest cover on erosion and run-off, as compared with grass; soil and water losses from soil and subsoil of important types originally the same; comparison of soil and water losses under crop rotations on eight important soils; and effect of length of slope on erosion and run-off.

In discussing the problem of the arid and semiarid lands of the West, Ralph H. Brown of the University of Minnesota emphasizes the necessity for improvements in irrigation practices to minimize water losses through this practice. An accompanying article by Shelford and Hanson sets forth recommendations for restoration of perennial grass cover and rodent control in the grasslands.

In an unusual and illuminating article, Reclamation of Wet and Overflow Lands, George J. Miller states that "the assumption that any wet, swamp, or marsh land is suitable for agriculture when drained has led to the undertaking of many unwise drainage projects, and consequent disappointment and loss. Some of these enterprises should be abandoned and the swamp land utilized for more appropriate purposes such as forests, wildlife refuges, or marsh hay land * * * Further developments should be based on clearly demonstrated need for cropland, public welfare service such as maintenance of health and prevention of floods, ample evidence that the probable returns from drainage will warrant the investment, and careful consideration of the possibility that the wet lands, especially swamp lands, may not really be worth more to man if left in their natural state."

Many other phases of the subject of conservation are treated in the book—floods and flood control, wildlife, waterways and water power, forests and tree crops, mineral resources, natural resources and the manufacturing industry—and the present conservation movement in America is set forth as a field of national endeavor and long-term planning.

The book contains many illustrations, reference maps, agricultural data in tabular form, bibliography and index.

AN OUTLINE OF GENERAL FORESTRY. By Joseph S. Illick. New York. 1936

It is gratifying to note that this handbook has been brought up to date with new chapters dealing with special forestry activities in the general soil-conservation program. With stress laid upon the importance of tree plantings on eroding steep slopes, in gullies, on stream or road banks, and on depleted lands removed from cultivation, the general information concerning the many phases of forest maintenance becomes increasingly valuable.

The handbook is designed primarily for students of forestry, but it may also be of service to laymen and untrained forest workers engaged in a wide range of forest activities. Of interest are the chapters on the general forest situation in the United States today, and progress in State and Federal forestry. Within the latter is to be found an outline of the principal forestry activities of the Soil Conservation Service, including woodlot improvement, reforestation for erosion control, nursery operations, seed collections, and protection against fire, insects, diseases, and other destructive agents.

The general information concerning production and care of forests, equipment, management and utilization of forest products, and forest research, is systematically outlined and assembled. For the benefit of students of forestry the author has included a section dealing with forest education and fields of employment in forestry.

GEOGRAPHY, AN INTRODUCTION TO HUMAN ECOLOGY. By C. Langdon White and George T. Renner. New York and London. 1936

A new book on the study of human groups and their relationships to the earth. The various elements of the natural environment are presented, together with a general evaluation of the part each plays in human ecology. Beginning with the climatic factor, each climatic type is treated with regard to distinguishing characteristics, regions on the earth's surface, plant and animal geography, distribution of population, and economic, social, and political economy. The text contains chapters on soils and their characteristics and uses, with sections dealing with the problem of soil erosion and depletion and methods of control.

The book contains over 300 illustrations.

GOVERNMENT PUBLICATIONS AND THEIR USE. By Laurence F. Schmeckebier. Washington. 1936.

A guide to the utilization of Government publications with specific descriptions of catalogs and indexes, bibliographies, and classifications. Contains information concerning the availability of publications dealing with foreign affairs and relations, reports on operations of departments and bureaus, organization and personnel, and technical subjects. A comprehensive chapter on map collections is included Appendix contains a list of the depository libraries of the United States.

Trees for Cash

(*Continued from p. 213*)

such as continually arise in carrying on farm operations. Mr. Groves states that it is impossible, for such purposes, to place a dollar-and-cents value on the farm woods.

A study of the 150-acre woodland on a 200-acre farm in the Bedford, Ind., watershed project area indicates a possible net return of $8 per acre per year based on present growing stock and market prices. The total labor earnings for this farm, for 1935 and the preceding 10 years, amounted to about $242.94 per year. The woodland was used only for limited grazing and fuelwood production.

Under the reorganization plan for this farm, as prepared by the Soil Conservation Service, 150 acres has been set aside as permanent protected woodland. The estimated increase in income from better crop and pasture-land management on the 150 acres so used amounts to about 59 percent. This increase, added to that resulting from woodland-management practices, indicates a total labor income (in sight) of $1,500 per year, or more than five times that secured prior to the replanning of this farm by the Service.

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